DESIGN OF A 20,000 K. V. A. GENERATING STATION

BY

H. C. KIHLSTROM
J. J. O'ROURKE

ARMOUR INSTITUTE OF TECHNOLOGY

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DESIGN OF A 20,000 K. V. A. GENERATING STATION

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HARRY C. KIHLSTROM AND JAMES J. O'ROURKE

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OUTLINE

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and of a
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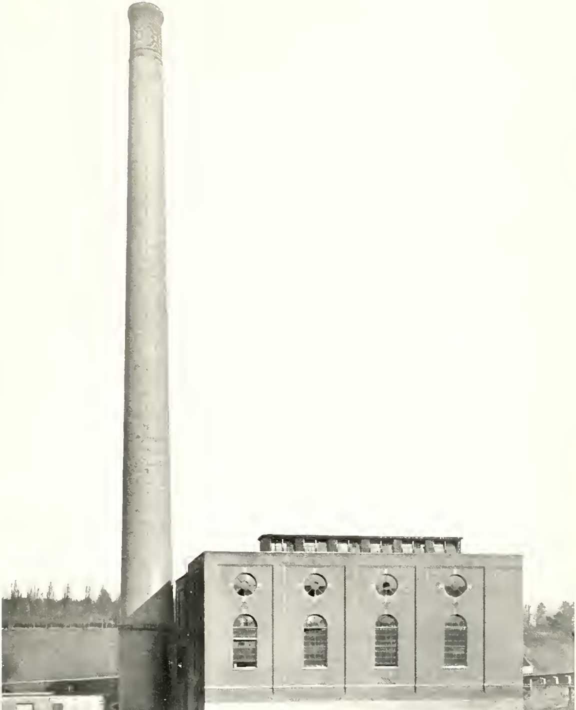


Design of a 20000 K.W. Generating Station
and a 2000 K.W. Substation.

General description of building and apparatus.

The object of this thesis is to design a generating station to supply power to a railroad and light to a small town, the amount of power required being shown by the load curve on the next page. The magnitude of the load at different times of the day is shown, the maximum railway load being 13,500 K.W. at 5 P.M., and the maximum lighting load being 4,500 K.W. at 6 P.M., and the total railway and lighting load being 17,400 K.W. at 5 P.M. It is evident, then, that the station must be designed to deliver 17,400 K.W. It was therefore decided to install four 5000 K.W. generating units and build the rest of the station with that as a nucleus. The object of installing four 5000 K.W. units is to operate three regularly, and to use the fourth as an emergency unit when one of the others is being repaired. The number of machines in operation during the twenty-four hours will be as follows:

From midnight	to 5 A.M.	-	1 unit
" 5 A.M.	" 6 A.M.	-	2 units
" 6 A.M.	"10 A.M.	-	3 units
" 10 A.M.	" 3 P.M.	-	2 units
" 3 P.M.	" 9 P.M.	-	3 units
" 9 P.M.	" midnight	-	2 units

It is evident that the three units will not be overloaded except from 4 P.M. to 7 P.M., when the maximum load on any machine will be 17,400 ÷ 3 = 5800 K.W. or 16% overload, which the machine can easily carry.

The generating station is not placed near any natural


K.W.
20000
15000
10000
5000
Total Load
Railway Load
Lighting Load
12
3 A.M.
6 A.M.
9 AM.
NOON
3 P.M.
6 P.M.
9 P.M.
12 MIDNIGHT.

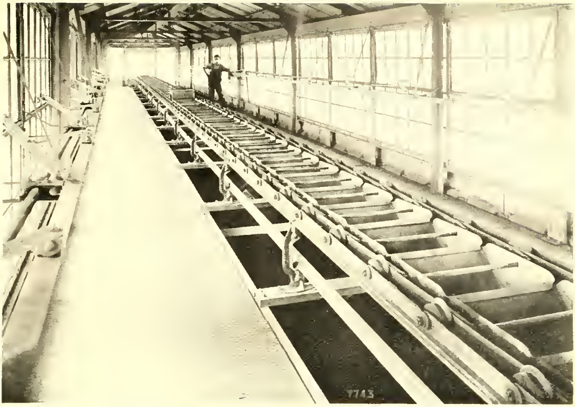
supply of water; the cold water for condenser purposes is taken by means of an underground conduit, from a nearby town or city. The excess water and condensate is carried back to the town or city sewer by means of another underground conduit. It is not placed near any coal mine, and hence the coal must be drawn to it by railroad. It is 200 feet long, 93 feet wide and 95 feet high, to the top of the roof truss above the boiler room, 87 feet high above the engine room, and 50 feet high above the transformer room. The general arrangement of the apparatus is as shown on the blue prints included in this thesis, and as described below. The detailed descriptions of the apparatus are as given further on under their respective headings. For convenience here let us assume that as the plan of the building, as shown on an accompanying blue print, is viewed, the top is north and the bottom south.

The coal is taken in on the east side of the building, in a car by means of a standard gauge track, and dumped into a pit, as described in detail further on. The boilers are four in number, running the length of the boiler room. The space between the front of the boilers and the wall is 22 feet, which is sufficient to allow for taking out the chain grate and working around it.

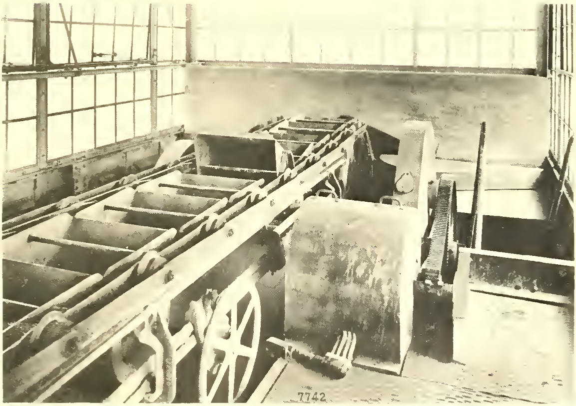
The engine room is equipped with four 5000 K.W. steam turbine alternators, and all the electrical and mechanical auxiliaries which will be described in detail later. The auxiliaries are located in the basement.

There are seven steam and water headers as follows:

The main steam header- 14 inches in diameter, is placed on the north wall of the boiler room, 27 feet above the floor. It



Peck Carrier over Storage Bin, W. H. Grundy Co.



Driving Machinery for Peck Carrier in Boiler House, W. H. Grundy Co.

is supported by steel braces as shown, every 20 feet. It is 14 inches in diameter.

The auxiliary steam header- 8 inches in diameter, is located on the north wall of the boiler room below the floor. It supplies the steam for the auxiliaries.

The feed water header, 12 inches in diameter, is placed directly below the auxiliary steam header. It is supplied with water from the feed water heaters,through the feed water pumps, and supplies feed water to the boilers.

The exhaust header is 14 inches in diameter, and is placed directly below the feed water header. It receives the exhaust steam from the auxiliaries and supplies the feed water heaters with steam to heat the feed water.

The condensate header, 8 inches in diameter, is located below the boilers. It receives the condensate from the hot well pump and feeds into the feed water heater.

The blow-off header is located directly underneath the condensate header. It is 8 inches in diameter. It is used to drain any one of the boilers whenever necessary.

The auxiliary feed water heater is placed above the main steam header. It is 12 inches in diameter, and acts in parallel with the main feed water header.

There is also a pipe leading from the cold water main to the boilers through the feed water pump, to supply cold water to the boilers in case one or more feed water heaters are out of service. All of the pipes leading from these headers to the auxiliaries are equipped with valves wherever feasible.

There is a 25-ton traveling crane in the engine room, running its entire length, to facilitate the moving of any heavy piece of apparatus.

The roofs of the boiler room and of the engine room are held by steel roof trusses, as shown in the cross-section view.

The switch gallery is located on the north wall of the engine room, sufficiently low to clear the traveling crane. North of the engine room are the switch and transformer rooms. The current limiting reactances are placed on the floor below the transformer room, which is below the switch room. The switch room is on the same level with the switch gallery.

The lightning arrester is placed on the roof of the switch room.

The two chimneys are made of riveted steel plates. They rest on concrete foundations and are secured to it by means of sunken bolts. They are held in place by means of tension cables attached to the roof.

Mechanical Equipment

(1) BOILER ROOM

(a) BOILERS:

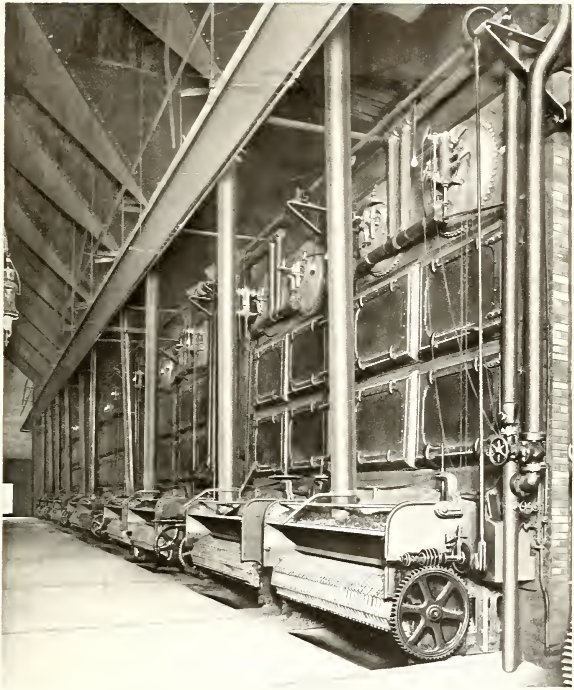
The design calls for 5000 boiler horsepower, made up of five sets of two boilers each, arranged in a single row. Each set or battery has two 500 B.H.P. units of the Babcock and Wilcox, longitudinal drum, inclined tube type. Boilers have the B. & W. automatic stoker.

The longitudinal drum construction: The heating surface of this type of boiler is made up of a drum or drums, depending on the width of the boiler extending longitudinally over the other pressure parts. To the drums there are connected through cross boxes at either end of the sections, which are made up of headers or tubes . At the lower end of the sections there is a mud drum extending entirely across the setting, and connected to all sections. The connections between all parts are by short lengths of tubes expanded into bored seats.

The drums are of three sheets of such thickness as to give the required factor of safety , under the maximum pressure used. Circular seams are lap riveted. All rivets in this make of boiler are driven by hydraulic pressure, and held in place until black.

The tubes are expanded into headers of the form shown in the cut. The headers are of wrought steel.

The mud drum to which the sections are attached at the lower end of the rear headers, is a forged steel box $7\frac{1}{4}$ inches square. The mud drum is furnished with hand holes for cleaning. The blow-off



connection is tapped from the drum.

Boilers of the longitudinal drum type are suspended front and rear from wrought steel supporting frames entirely independent of the brickwork. This allows for the expansion and contraction of the pressure parts without straining either the boiler or the brickwork, and also allows of brickwork repair or renewal without in any way disturbing the boiler or its connections.

FITTINGS: Each boiler is provided with the following fittings as part of the equipment:

Blow-off connections and valves attached to the mud drum.
Safety valves placed on nozzles on the steam drums.
A water column connected to the front of the drum.
A steam gauge at the front of the boiler.
Feed water connections and valves.

The gases of combustion in this type of boiler are led over the heating surface by two baffles. The cuts show the form of construction of the boilers.

Super-heaters are used in this design. These are also B. & W. of the type shown in the cut.

Advantages of superheated steam: Experience has unquestionably shown that the use of superheated steam with turbines leads to an appreciable gain in economy. This fact is so well established in engineering practice that turbines are not generally used with saturated steam. Where saturated steam is used with turbines, even when it is dry upon entering the first stage, the work done in expanding the steam through progressive stages causes the condensation of a sufficient amount of steam to give trouble through the presence of water in the low pressure stages. The water rate of a large economical steam turbine with superheated steam is reduced about

BABCOCK & WILCOX SUPERHEATER AS ORDINARILY APPLIED TO BABCOCK & WILCOX BOILERS

one per cent. for every twelve degrees of superheat up to 200 degrees of superheat. To superheat one pound of steam twelve degrees requires about 7 B.T.U. and if 1050 B.T.U. are required at the boiler to evaporate one pound of water into saturated steam from the temperature of the feed water, the heat required for the superheated steam would be 1057 B.T.U. One per cent. of saving in water consumption would correspond, therefore, to a net saving of about one-third of one per cent. in the coal consumption.

Calculation of boiler horsepower:

Back pressure on turbines - 2" of mercury

16# steam consumed per K.W.hr. B.H.P. = $3\frac{1}{2}$ K.W.hr. = $\frac{56}{16}$
(Assuming a capacity of 175% overload)
125° superheat, 215# per sq. in. abs.

$$\frac{17500}{3.5} = 5000 \text{ B.H.P.}$$

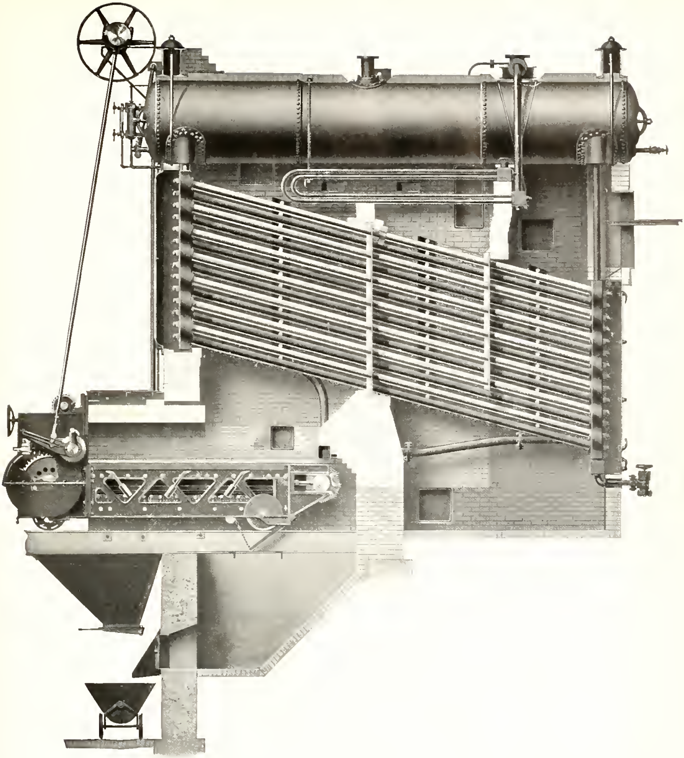
Approximately .03 of this is used for auxiliaries. 5000x .03 = 150 B.H.P.

The feed water heater is of the horizontal pan type, and is located above the boilers. The exhaust steam enters through an oil filter, and completely surrounds the pans. The feed water in flowing over the sides and the bottoms of the pans comes in direct contact with the steam.

There are two self-supporting stacks; one is nine feet in diameter, and the other is seven and one-half feet in diameter. The height of each is 200 feet. The construction is of steel plates with lining. The bases are flared, and are riveted to a heavy cast iron plate bolted to a concrete foundation of sufficient mass to insure stability.

(b) COAL AND ASH HANDLING APPARATUS:

The coal is received from the car which is run over the coal hopper. Each rail of the railroad track is supported over the

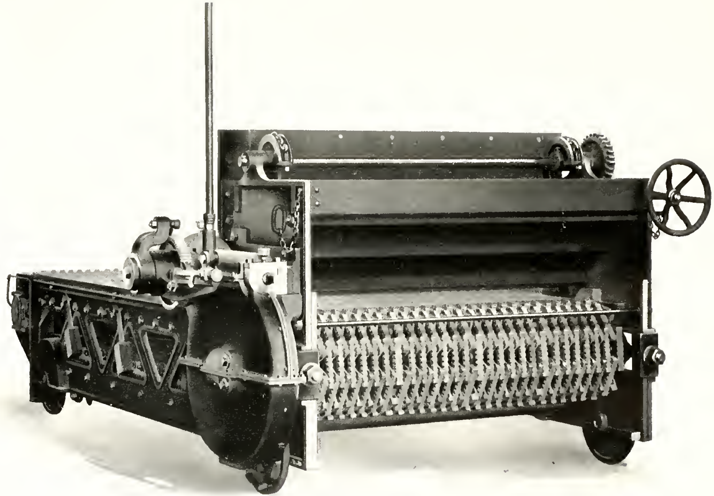


BABCOCK & WILCOX SUPERHEATER INSTALLED IN A WROUGHT-STEEL VERTICAL HEADER BABCOCK & WILCOX BOILER, EQUIPPED WITH A BABCOCK & WILCOX CHAIN GRATE STOKER

coal crusher pit by means of two 15 in. I-beams, with plates at the top and bottom, to which the rails are clamped. Suspended from these girders and from a channel beam, is the track hopper, made of one-quarter inch steel, and measuring about ten feet long and eight feet wide. The bottom of this coal hopper is formed by the plate of the reciprocating feeder, which is also of one-quarter inch steel, and which is supported on rollers that are in turn supported by bearings attached to the feeder sides at the bottom of the hopper. This feeder plate is given a reciprocating motion by means of an eccentric, carried by a counter shaft geared to one of the crusher roll shafts. As the plate moves forward, the coal resting on it also moves forward, and other coal fills in the space which is formed at the rear. As the plate moves back, the coal at the forward end falls into the crusher, and as this movement is repeated twenty-three times per minute it gives practically a regular feed to the crusher.

The coal crusher is of the two roll type, with hard chilled rolls twenty inches in diameter, by twenty-four inches face. The rolls revolve at 40 R.P.M. The roll shafts are geared together by special long tooth gears, and the bearings on one of the roll shafts are backed up by springs, in order that one roll can move back in case some hard foreign substance gets in between the rolls. One of the roll shafts is geared to a counter shaft, supported in bearings on the cast iron crusher frame, and this counter shaft is driven by means of a belt drive from a 15 H.P. motor running at 900 R.P.M.

The Peck carrier which elevates and distributes the coal, and which takes the ashes up and deposits them in the ash receiver, is an 18 in. x 21 in., that is, the pitch of the chain is 18 in. and the



BABCOCK & WILCOX CHAIN GRATE STOKER

width of the bucket 21 in. The buckets are 18 in. in length, and are cast in one piece of malleable iron about 3/16 in. thick., with over-lapping lips to prevent the material from spilling between them when it is fed into them. The carrier is to be driven at a speed of 30 ft. per minute by an electric motor.

The coal bunkers extend above the boilers, and are rectangular. Each set of two boilers has a bunker, which branches about half-way down, feeding each boiler unit. The bunkers are of 3/8" sheet steel, and were designed to hold a two days supply.

The ash receiver is supported above the coal track, and is a cylindrical sheet steel container ten feet in diameter.

The automatic chain grate stokers are of the B. & W. make, and are highly desirable in a plant of this size, because of their advantage in conjunction with the other coal and ash handling equipment. The cut shows this stoker.

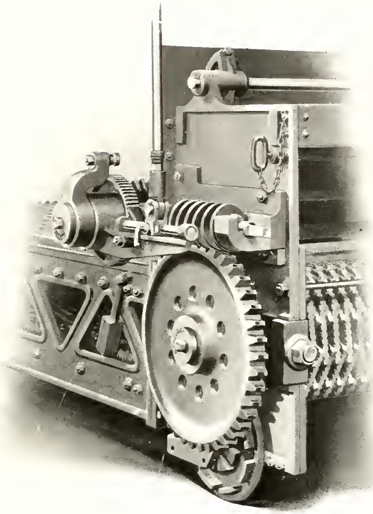
(2) ENGINE ROOM AND AUXILIARIES.

The main generating units are 5000 K.V.A. 5 stage, 3600 R.P.M. condensing Curtis steam turbine sets. Each unit rests on three concrete supports. Between the two supports on the turbine end the surface condenser rests, on ledges or shoulders of the supports. Below the condenser, in a small pit, is the condensate pump, which is steam driven. Each of the four units has its own circulating water pump, condensate pump, and dry vacuum pump.

The main unit turbines take steam at 215# abs.

Auxiliaries take steam from the auxiliary steam header, and exhaust into the exhaust header.

The condenser cooling water discharges into the discharge



DRIVING MECHANISM OF BABCOCK & WILCOX CHAIN GRATE STOKER WITH CASING REMOVED

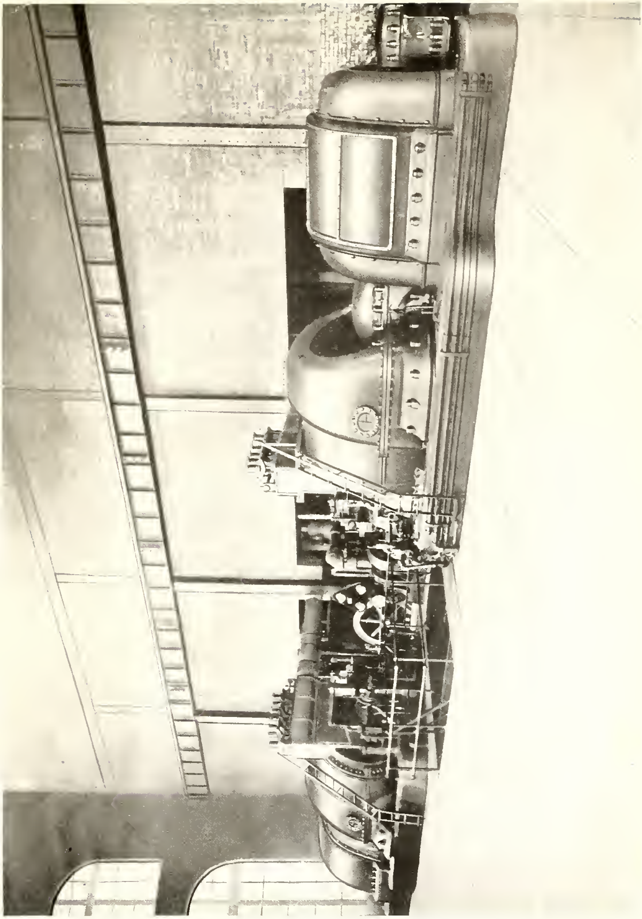
tunnel, and the intake is taken from the cold water tunnel. Each tunnel is circular and $3\frac{1}{2}$ feet in diameter.

Pipe lines to and from the boiler room are grouped together as much as possible under the cross walks.

An open-air exhaust leads from each condenser and from the feed water heater, to the air above the boiler room roof. Each pipe has a valve near the unit. These pipes are of one-quarter inch steel, lap riveted, 20 inches in diameter.

There are two steam turbine driven centrifugal feed water pumps. Valves are arranged so that cold water may be drawn in, and in order that either pump may be used.

One of the exciters is steam turbine driven.



ELECTRICAL EQUIPMENT.

The electrical equipment of the 20000 KW. generating station consists of the following apparatus:

Engine Room: Four 5000 K.W. A.C. generators and various K switches and relays, as described in a following paragraph, and shown on the blue print of the wiring diagram of the generating station.

Switchboard: The items of which are hereinafter enumerated.

Transformer Room: Three step-up transformers for each machine connected in Y with the neutral grounded, on the high-tension side, and in delta on the low tension side.

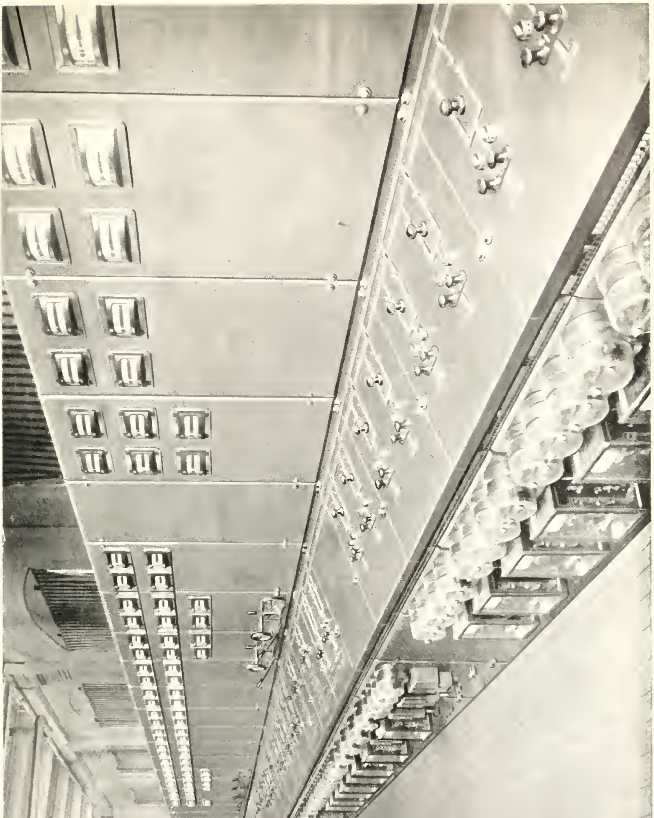
THE ALTERNATORS: The alternators to be used are of the revolving field type, direct connected to Curtis steam turbines.

"Turbine generators necessarily run at very high speeds, which necessitate a rotating element of small diameter and extreme mechanical strength. A large electrical output is generated from a relatively small mass of copper and iron, which requires the dissipation of a large amount of heat from comparatively small radiating surfaces."

The armature coils are form wound and easily assembled and removed. They are heavily insulated with ample factors of safety for the specific generator voltage of 6600 volts. The slots are closed with wedges dovetailed into the iron punchings. Ample ducts provide free passage of ventilating air. The armature is equipped with an exploring coil or temperature detector, located in the hottest parts, between the winding and iron and between adjacent coils.

" The field coils are insulated to withstand high temperatures and the character of the insulating material is such that temperatures greatly in excess of normal will not result in injury. Both windings and iron are designed with liberal margin for maintaining full voltage on low power-factor load. The completed field is a compact rotating element of great mechanical strength. The surface is practically smooth. The end windings which necessarily extend beyond the punchings are held against centrifugal strain by heavy steel retaining bands. Fans are provided at the ends of the field structure which draw large quantities of air to ventilate both field and armature. The course of this air is so directed by the armature casing that it can be drawn from a definite source of cool supply and similarly discharged. The revolving field consists of a solid steel forging, with slots for the coils milled in its surface."

Each generator is connected three phase in Y with the neutral grounded. In the connection from neutral to ground is a K switch in conjunction with a relay. When there is a high circulating current from neutral to ground the relay operates and lights a red pilot light situated on the switchboard. The generator is also equipped with an automatic overload relay working in conjunction with a K switch, which throws the machine off the line in case of a short circuit or other dangerous disturbance. This K switch is placed between the machine and the low tension bus. Each generator is connected to the low tension bus through a K switch equipped with an overload relay which immediately throws the machine off the line in case of a short between any other machine and this one. Beyond the connection between the low tension bus and the machine is a K



switch connecting the machine to its transformer. This switch also acts in conjunction with an overload relay. The transformer is connected in delta on the low tension side end in Y on the high tension side. Between the high tension side and the high tension lines is a K switch equipped with an overload relay.

All the items enumerated in the preceding paragraph are duplicated for each of the four generators.

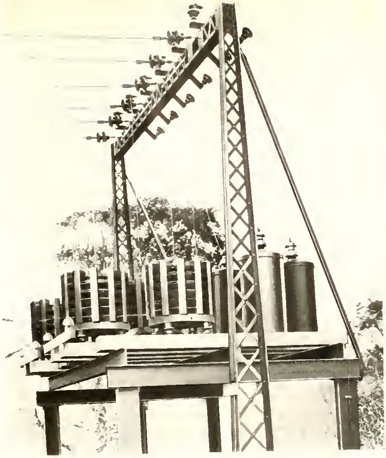
There is also a storage battery of 60 cells used in parallel with the motor generator set for supplying the DC operating busses, which in turn excite the fields of the generators, the K switches, and light the pilot lights.

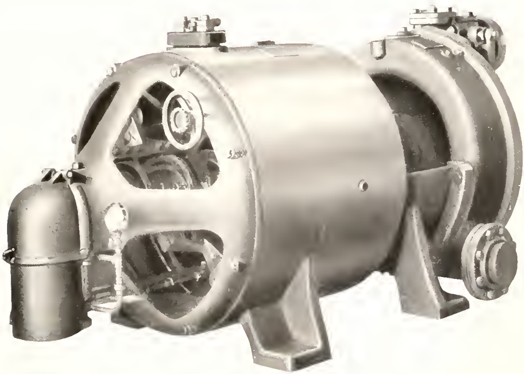
THE SWITCHBOARD: The switchboard consists of seven panels. Four are devoted to throwing the four generators on and off the line. Each one of these four is equipped as follows:

3 Ammeters- one for each phase.
1 Power factor meter.
1 Indicating watt meter.
1 Field ammeter.
1 Switch for connecting the neutral of the machine to ground.
1 Switch for throwing the machine on to the low tension bus.
1 Field switch.
1 Field rheostat.
1 Switch for throwing the transformer on to the high tension bus.
1 Switch for throwing the low tension side of the transformer on to generator.
1 Switch for governor control.
1 Exciter field switch.

One panel containing:

1 Ammeter- one for each feeder.
1 Ground ammeter.
1 Switch for connecting the two halves of the high tension bus.
1 Switch for connecting the two halves of the low tension bus.
1 Switch to short circuit the current limiting reactances on the low tension busses.





35-Kw., 125- or 250-Volt D.C. Curtis Steam Turbine

1 Switch for each of the four sets of
feeders.

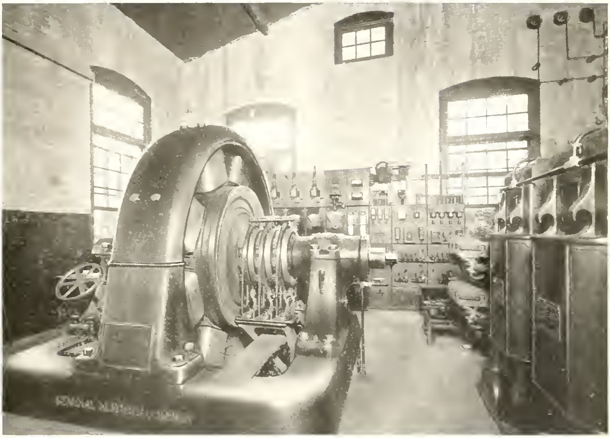
One panel containing:

1 A.C. ammeter for the induction motor which drives the D.C. generator, which excites the operating bus.
1 Exciter voltmeter.
1 Motor switch.
1 Generator switch.
1 Rheostat.
1 Field switch.

One panel containing:

1 D.C. ammeter for the D.C. generator.
1 Ground determinor.

The station is also equipped with the usual protective devices in the form of lightning arresters.



THE SUBSTATION.

The substation is used to take care of part of the railway load. It transforms 6600 volt A.C., which is fed to it from the generating station into 550 volts D.C. for railway use. The main equipment is as follows:

2 2000 K.W. synchronous connectors.
6 K type oil switches.
4 closing relays, C-1 and C-2.
3 Reactances in the high tension busses.
2 3-phase open delta instrument transformers.
2 Overload relays.
2 Banks of transformers- 6600, 550 volts, 3-phase.
2 Surge arrestors, on the A.C. side.
2 " " " " D.C. "

All the switches, pilot lamps, field regulating devices, bus bars, synchronizer and all the minor equipment, as shown on the drawing of the wiring layout of the substation.

The operation of the various items is as follows:

Method of throwing high tension transformers onto line-

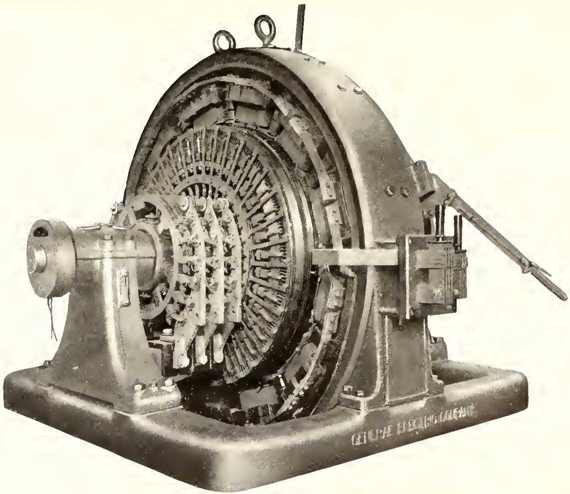
To throw the transformers onto the line, either one of the switches K-1 or K-2, must be closed. To close K-1 throw the knife switch S-1 up, which sends a current through C-1, thus closing G-1. The current then flows through the switch K-2 (in 3 and out 1) without causing any change in the position of K-2. The gap G-1 being closed, it takes current from the operating bus, through G-1, through the red pilot lamp, through the closing coil in K-1, and back to the operating bus. In the same way switch K-2 can be thrown in by manipulating switch S-2 in the same manner in which switch S-1 was employed to operate switch K-1. In order to throw the transformers off the line both S-1 and S-2 must be thrown down if both K-1 and K-2 are closed, (only one if either is open.) By doing this current

travels from the central bus through the opening coil of the K switch and back to the negative control bus.

The automatic overload release operates as follows: If the incoming lines to the high tension transformers are overloaded on account of some disturbance within the substation, the surge excites either one or both of the transformer coils T-1 and T-2, thus exciting either one or both of the relay coils R-1 and R-2, and closing the gap G-3. Then current travels from the positive operating bus, through G-3, through the opening coils of K-1 and K-2, and through the green pilot lamp, and thence back to the negative control bus.

The high tension transformers are connected in delta on the high tension side, and so connected on the low tension side to supply 6 phase current to the converter. The converter is equipped with a starting switch S-3, which when thrown upward supplies one-half voltage for starting, and when thrown down, full voltage for running. Current limiting reactances are placed between the collector rings and the switch S-3.

The switchboard equipment on the A.C. side consists of the usual pilot lamps, whose operation has been discussed before; an ammeter connected across the current coil T-1 of the overload relay; a voltmeter connected across the pressure T-3; and a recording wattmeter, whose pressure terminals are connected across T-3, and whose current terminals are connected across T-2. The usual voltmeter and synchronizing plugs are mounted on the switchboard. There is one A.C. panel for each converter.



STANDARD 1500-KW., 600-VOLT, 60-CYCLE
SYNCHRONOUS CONVERTER

The equipment on the D.C. panels consists of a circuit breaker, ammeter, wattmeter, an auxiliary switch with pilot lamps, and main switch. There is one for each machine.

There is one D.C. panel equipped with an ammeter, a voltmeter and wattmeter to measure the total D.C. power delivered.

There are two feeder panels equipped with an ammeter and a circuit breaker, a single throw switch and a kicking coil.

THE SYNCHRONOUS CONVERTER.

The 1000 K.W. commutating pole synchronous converter introduced by the General Electric Company is practically a standard design for all the larger sizes, and will be used. The momentary overload capacity of the machine (three times normal load) is especially suited for this substation.

The magnet frame is made of cast iron of high permeability. It is divided horizontally to allow the upper half to be easily removed for inspection, and for repairing the armature without entirely dismantling the machine. The two halves are connected by concealed bolts, thus keeping the symmetry of the machine intact. The pole pieces are made either of laminated or cast steel, with laminated steel pole shoes, bolted to the magnet frame. Heavy copper dampers are inserted in the pole faces to prevent hunting and to assist in starting from the A.C. side.

The field windings are wound in layers on spools, and are well insulated. Large ventilating ducts are provided to insure cool running.

" The laminations for the armature core are accurately punched and before being assembled are annealed and coated with insulating paint to reduce iron losses. The core is assembled on

an iron spider, and is held together and retained in position by either through bolts or keys. When through bolts are used they do not pass through the active part of the core. Ventilating ducts are provided at equally spaced intervals, which insures good ventilation of both the armature and the field spools."

The armature winding is made up of formed bars which are insulated before being assembled in the slots. The end windings are arranged so as to be thoroughly ventilated. They are held securely in position by binding bands. There are no binding bands over the core, the winding being held in place by wooden wedges.

" Any unbalancing in the magnetic circuits is corrected by equalizing connections which are mounted on the armature flange at the collector ring end. These equalizers eliminate also any unbalancing in current in the different armature circuits, and cause each set of direct current brushes to take their proper proportion of current, thus helping to keep the commutator in good condition and to prevent spotting of the commutator bars."

" The commutator bars are of hard drawn copper, and the mica between the bars is carefully selected with regard to its wearing and insulating properties, to give successful operation throughout the life of the commutator."

" The collector rings are made of a cast copper alloy; they have ample radiating surfaces to insure cool running, and are insulated with mica and horn fiber. They are mounted on a cast iron shell which is securely keyed to the shaft."

The bearings are of the ring self-oiling type, provided

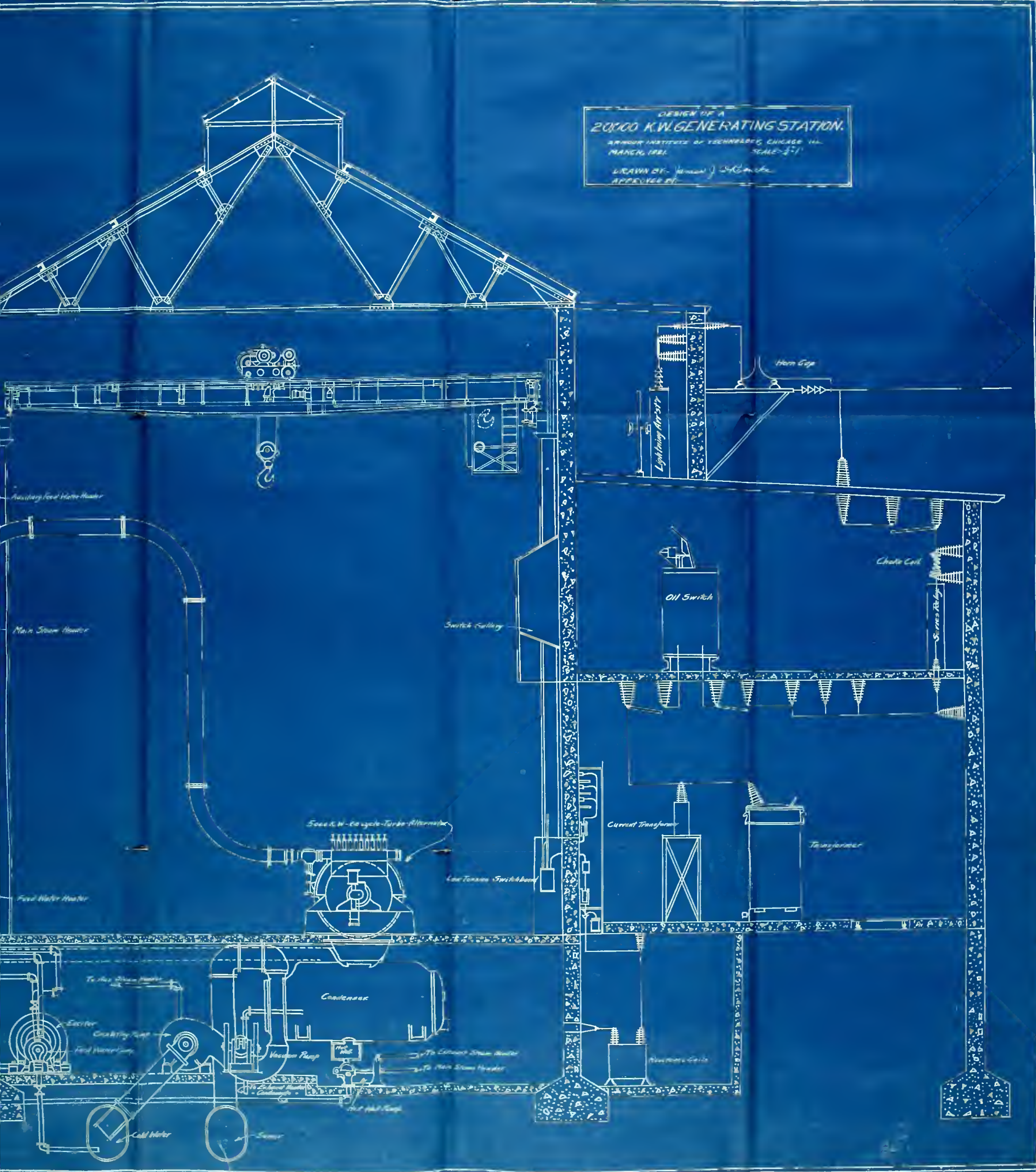
with large oil wells. The wearing surface is of babbitt and is renewable.

In order that the brushes may not wear grooves in the commutator and collector rings, it is necessary for the armature to have a slight reciprocating motion in a direction parallel to the shaft, such as is given to a belt-driven generator. To obtain this motion the converter is provided with an automatic, magnetic, end-play device which is simple, effective, durable and self-contained. This end-play device is self-starting. Current for the operation of the device is obtained from the direct current.

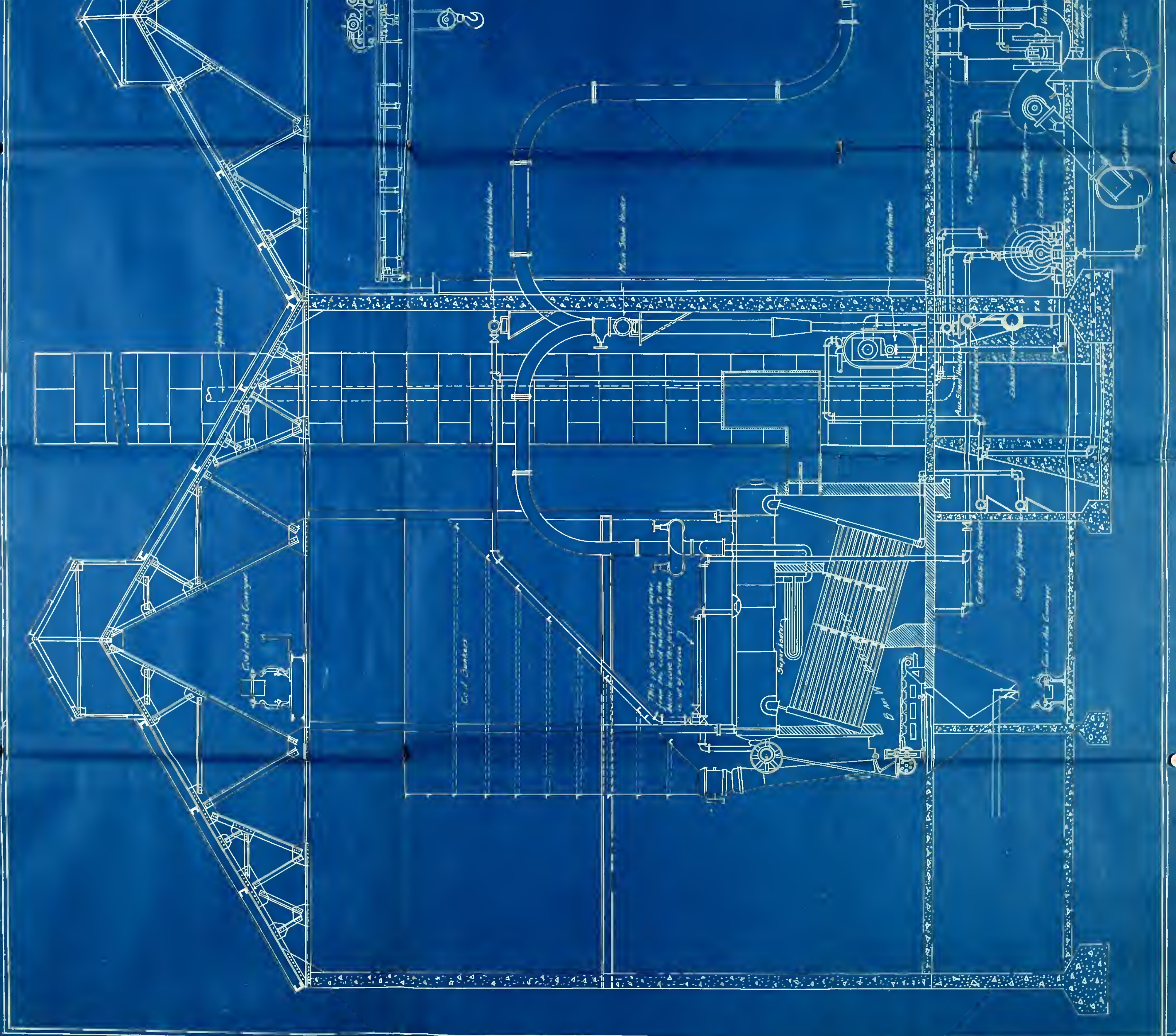
THE TRANSFORMERS.

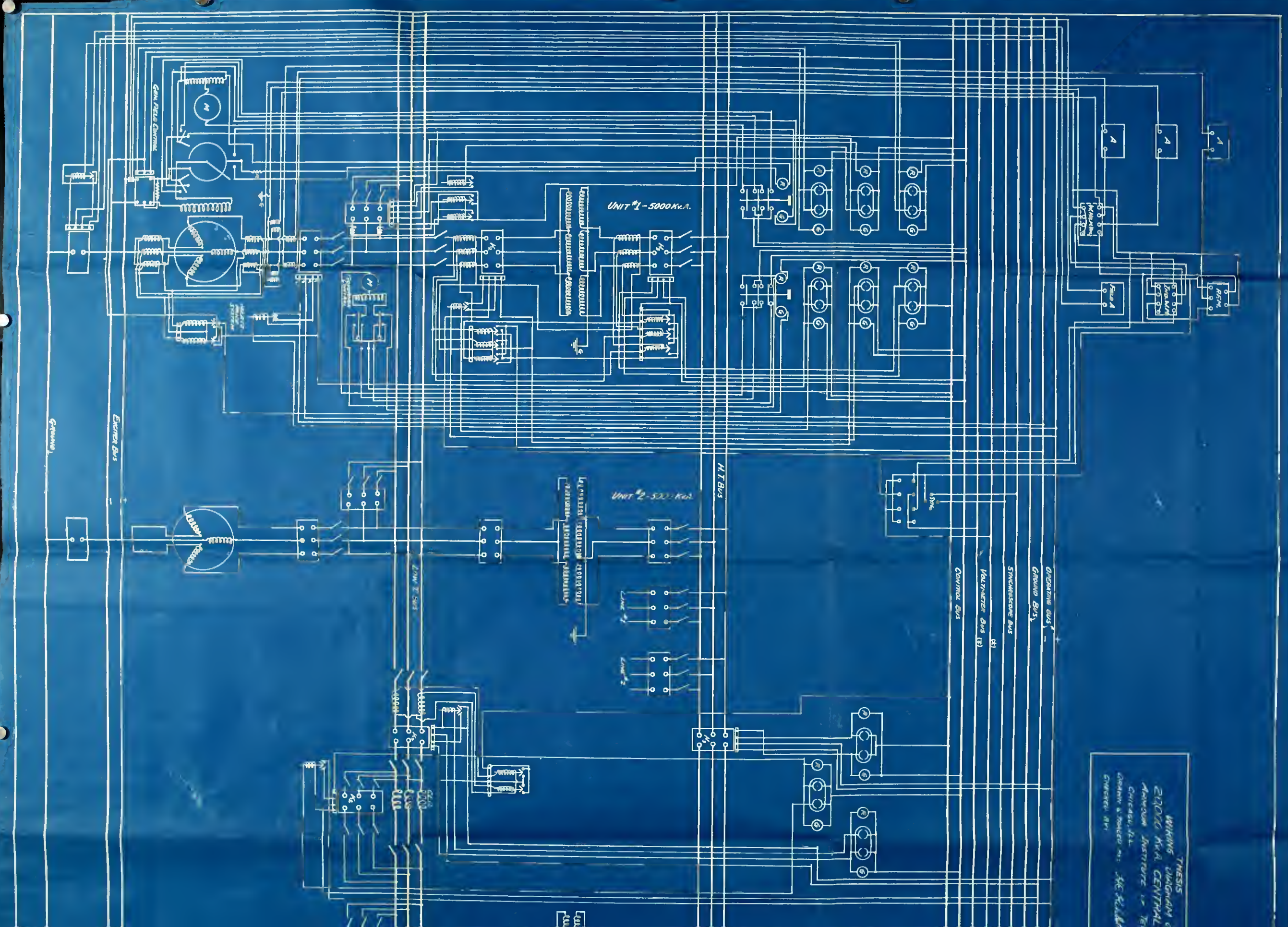
The transformers are six in number, one bank of three for each machine. They are connected in delta for the high tension side and for six-phase on the low tension side. Each one is of 350 K.W. capacity.

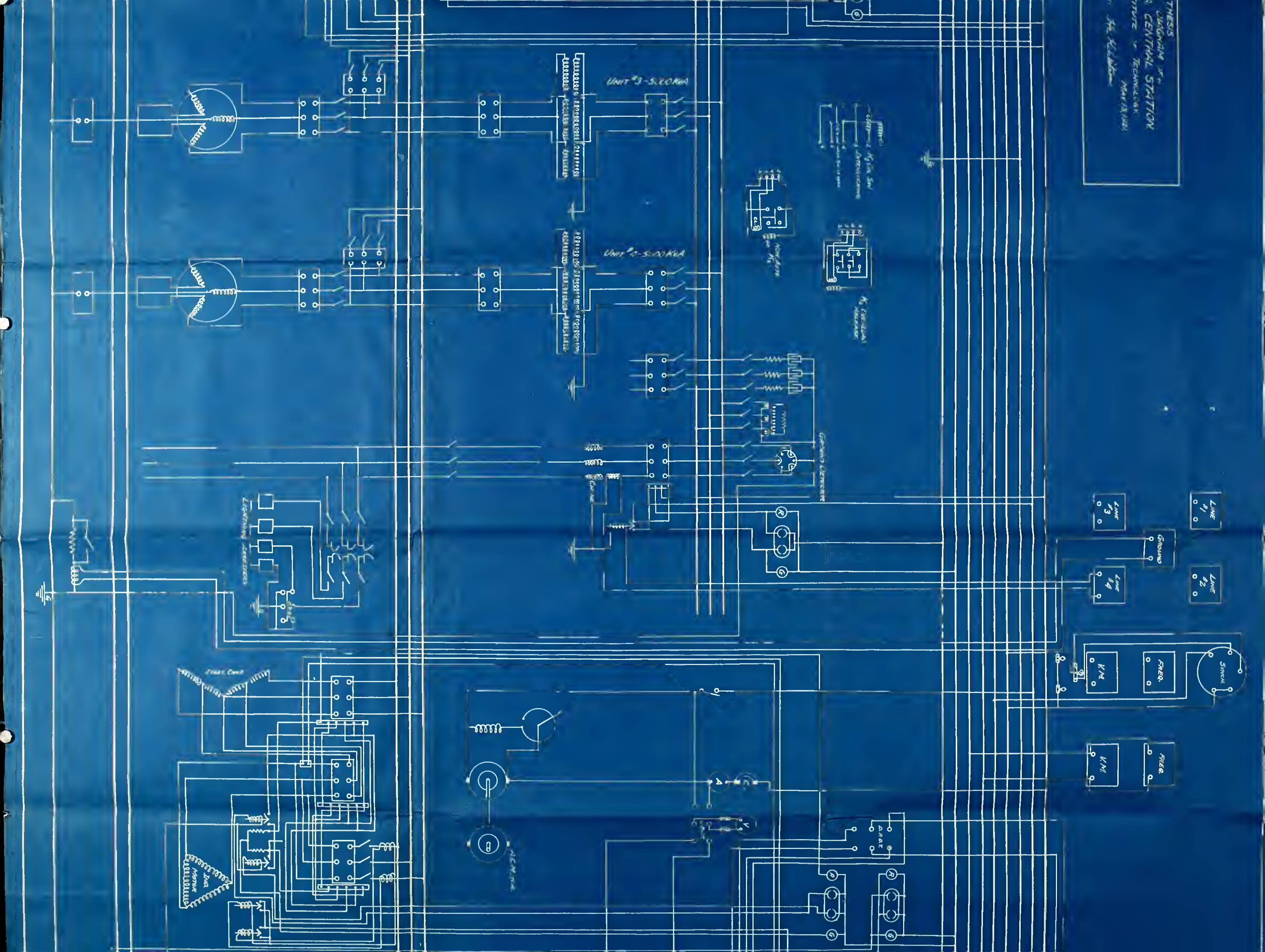
(Note: All matter in quotation marks is from the General Electric pamphlets.)

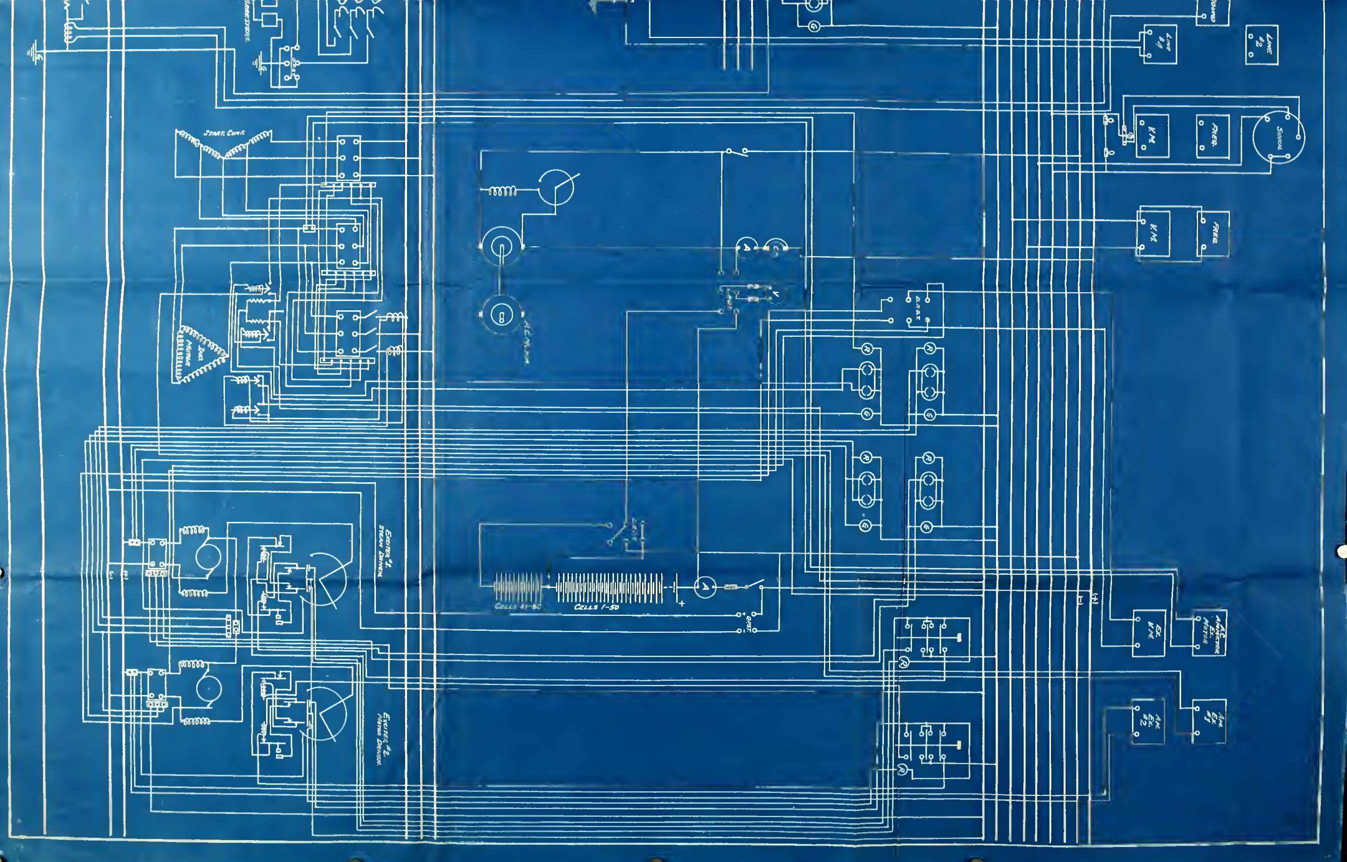


DESIGN OF A
20,000 K.W. GENERATING STATION.
ARMOUR INSTITUTE OF TECHNOLOGY, CHICAGO ILL.
DRAWN BY-
APPROVED BY-
Horn Gap
Lightning Arr'st'r
Choke Coil
Series Relay
Oil Switch
Switch Gallery
Current Transformer
Transformer
Low Tension Switchboard
Condenser
Vacuum Pump
Exciter
Cold Water
Sewer
Auxiliary Feed Water Heater
Main Steam Header
Feed Water Heater

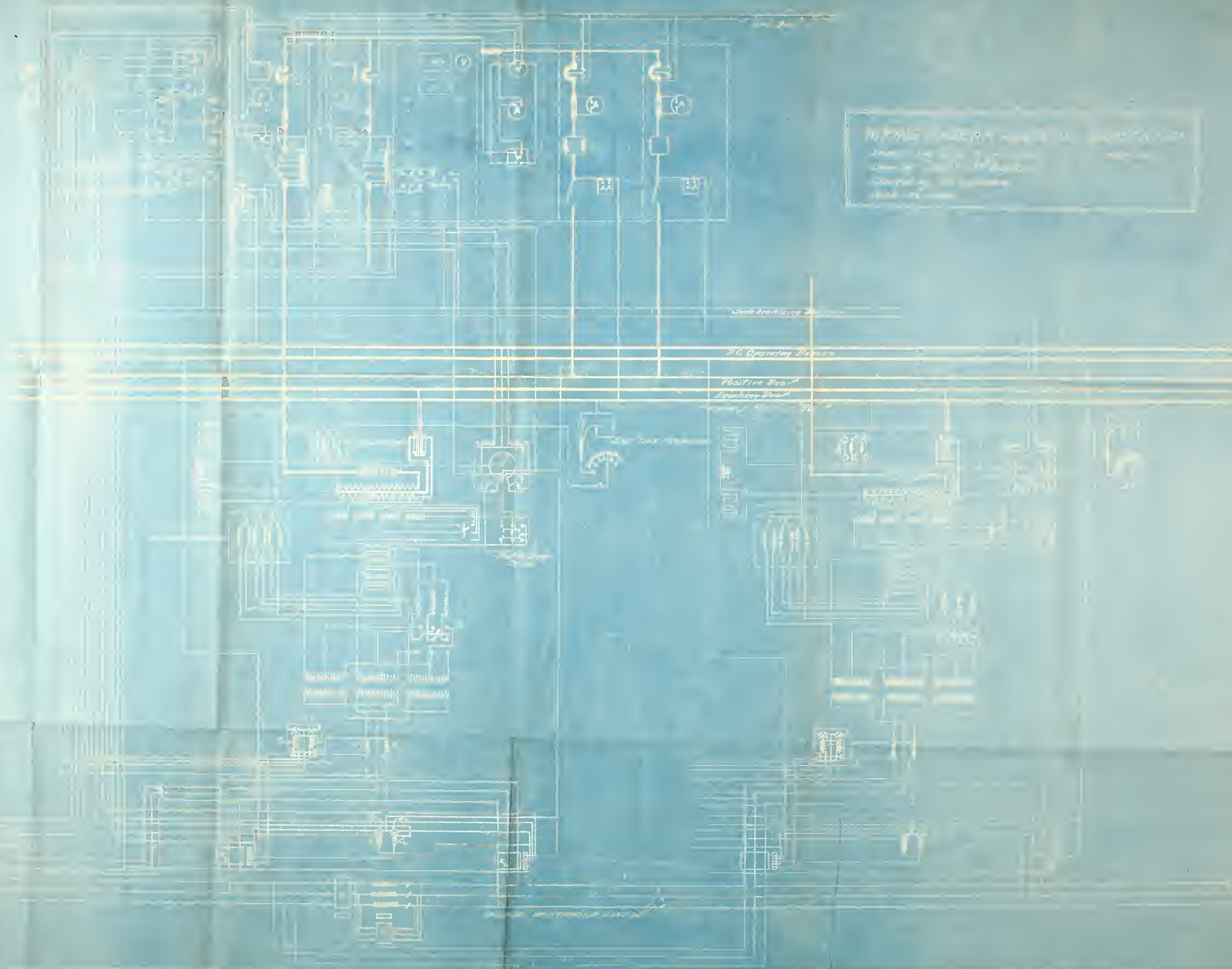

Main Steam Header
Feed Water Heater
Coal Bunkers
Superheater
B and W


GEN. FIELD CONTROL
UNIT #1 - 5000 KV.A.
GROUND
EXCITER BUS
H.T. BUS
LOW T. BUS
LINE #1
LINE #2
CONTROL BUS
VOLTMETER BUS (2)
SYNCHROSCOPE BUS
GROUND BUS
OPERATING BUS
THESIS
WIRING DIAGRAM
20000 KV.A. CENTRAL
ARMOUR INSTITUTE OF
CHICAGO, ILL.
DRAWN & TRACED BY:
CHECKED BY:


THESIS
CENTRAL STATION
UNIT #3-5000 KVA
UNIT #2-5000 KVA
LIGHTNING ARRESTERS
GROUND DETECTOR
LINE #1
LINE #2
LINE #3
LINE #4
GROUND
FREQ.
SYNCH.
K.W.
A
V
R
G



START. COMP.
MOTOR IND.
CELLS 1-50
EXCITER #1 STEAM DRIVEN
EXCITER #2 MOTOR DRIVEN
LINE #1
LINE #2
K.W.
FREQ.
SYNCH.
A.C. AMMETER EX. MOTOR
EX. K.W.


D.C. Operating Busses
Positive Bus
Equalizer Bus